Organic Electrochemical Transistor Incorporating an Ionogel as a Solid State Electrolyte for Lactate Sensing

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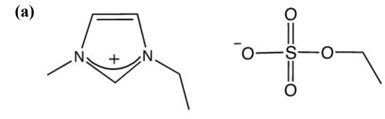
Introduction:

Room temperature Ionic liquids (RTILs) have evolved as a new type of solvent for biocatalysis, mainly due to their unique and tunable physical properties.[1] In addition, within the family of organic semiconductor-based sensors, organic electrochemical transistors (OECTs) have attracted particular interest.[2]

Here, we present a simple and robust biosensor, based on a OECT, capable of measuring lactic acid using a gel-like polymeric materials that endow RTIL (ionogel)[3] as solid-state electrolyte both to immobilise the enzyme and to serve as a supporting electrolyte.[4] This represents the first step towards the achievement of a fast, flexible, miniaturised and cheap way of measuring lactate concentration in sweat.

Experimental:

1-Ethyl-3-methylimidazolium ethyl-sulfate ionic liquid, $[C_2mIm][EtSO_4]$, was chosen because of its miscibility with water and bio-compatibility.



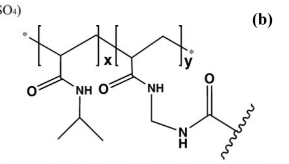


Fig 1: a) Chemical structure of the RTIL, b) hydrogel polymer (monomer molar ratio 100(x):4(y)).

The OECT is fabricated by standard lithography and it is made of 200 nm thick PEDOT:PSS film.

The hydrated RTIL mixture containing the lactate oxidase enzyme (LOx) was photo-polymerised using a UV irradiation source (λ = 365 nm) for 1 minute.

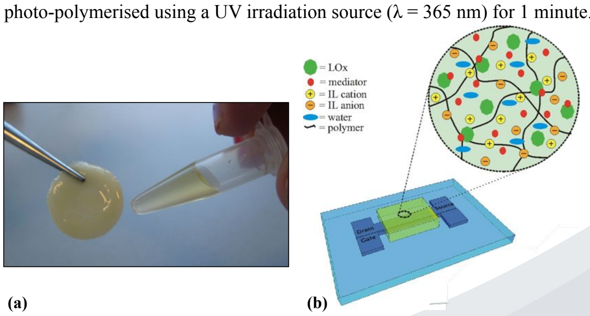


Fig 2: a) Ionogel after (left) and before polymerisation (right); b) schematic representation of the OECT device with ionogel/enzyme mixture.

Acknowledgement

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Results & Discussion:

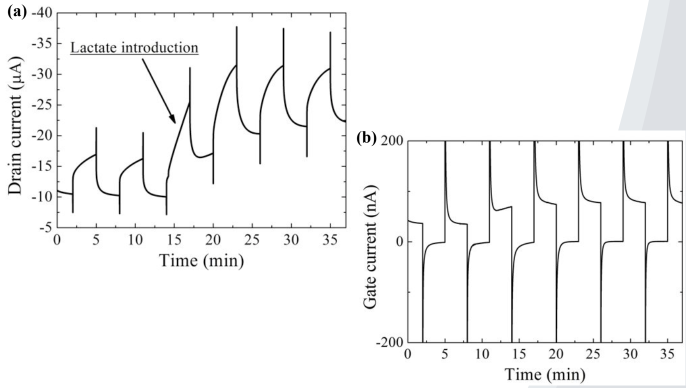
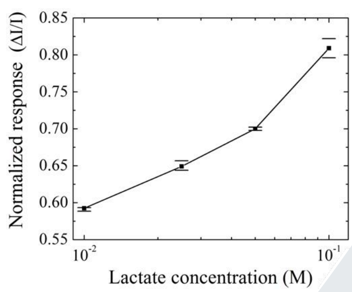
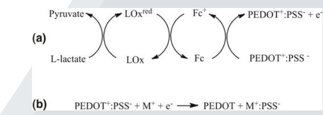


Fig 3: a) Drain current vs. time with addition of 25 mM lactate indicated by an arrow; b) corresponding gate current vs. time.



Current modulation (represented as the dimensionless quantity *ΔI/I*) of the OECT as a function of lactate concentration.



Series of reactions that take place upon introduction of the lactate.

Fig 4: Normalised response of the OECT vs. lactate concentration and reactions at the gate electrode (a) and at the channel (b) of the OECT.

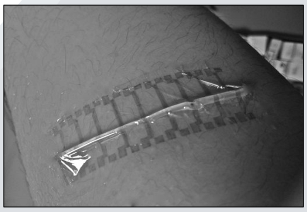


Fig 5: OECT with gel shown on a forearm.

Conclusions:

We demonstrate the detection of lactate in a relevant physiological range using an OECT sensor with an ionogel solid- state electrolyte. The significance of this work for sensing applications lies in the configuration of the sensor; we show for the first time a solid state electrolyte on a flexible transistor-based biosensor.

References

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[4] Khodagholy, D., V.F. Curto, K.J. Fraser, M. Gurfinkel, R. Byrne, D. Diamond, G. G. Malliaras, F. Benito-Lopez and R.M. Owens , J. Mat Chem, 2012, 22(**10**), 4440-4443